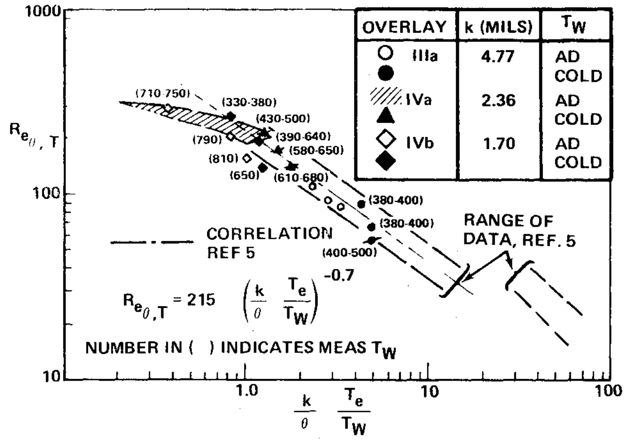

Fig. 2 Rough wall transition results showing comparison with correlation of Ref. 5.

hand side of Eq. (1) can be shown to reach a maximum when $M_e = 1.0$. Consequently, its value at the sonic point must exceed the empirical constant 255 before the transition location is determined as the position where the parameter equals 215. It should be noted that the stagnation point is approached as the value of the right-hand side of Eq. (1b) decreases. The present data are shown as open symbols for the adiabatic case and as filled symbols for the cold-wall condition. In the latter instance, the range of wall temperatures encountered on repeated runs is listed in parenthesies adjacent to the data point and the corresponding uncertainty in the transition coordinates is indicated by the short straight line drawn though the data point. The values of θ used in Fig. 2 were determined from theoretical laminar boundary-layer calculations for a smooth surface. For $\Delta > 1.0$, the agreement between the present results and Anderson's correlation is satisfactory and prompts the following comments. First, although the methods for manufacturing the surface texture differed in the two experiments, the observed agreement implies that the roughness characteristics are quite similar. Second, since the wind-tunnel facilities and the associated noise environment also differed, the agreement between the two experiments further suggests that transition was roughness dominated and that tunnel noise had litte effect on the results. Finally, considering the range of test conditions involved, the test results indicate that Anderson's location correlation is valid for wall temperatures ranging from 0.5 T_o to 1.0 T_o.

For $\Delta < 1.0$, however, the shaded band, representing the transition zone bounded by the dashed curves in Fig. 1, departs from the correlation given by Eq. (1b). These data correspond to transition aft on the nosetip where the onset criterion in Eq. (1a) predicts transition does not occur. The discrepancy may be attributed to differences in the experimental procedures. In the transient tests of Ref. 5 the transition location continuously moved aft during the test and, beyond the sonic point, may have flashed rapidly to the frustum, while for the steady-state condition of the present investigation, transition remained at a fixed location during the test. It is important to note that the trend of the present data for $\Delta < 1.0$ indicates a shift from the roughness-dominated situation (where $\Delta > 1.0$) to the smooth wall region where other effects, such as disturbances in the external stream, may be introduced. This remains an important technical topic whose resolution requires further investigation.

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Effects of Water Vapor on Thermal Shield Materials

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Introduction

THE vulnerability of several flexible thermal control materials to damage under conditions of high humidity was investigated. Deterioration of these materials would destroy their ability to protect spacecraft from excessive heating caused by orbital solar radiation. Exposure to a humid environment could result from failure of an air-conditioning unit at any time prior to launch.

In this study samples of ¼-mil aluminized Mylar, 1-mil aluminized Kapton, and 2-mil silvered Teflon, in the form of squares ½ to 3 in. on a side, were exposed to various controlled humidities and examined for deterioration. The samples were used, as received, without being cleaned or treated. It was discovered that the aluminized Mylar and aluminized Kapton were unaffected by the water vapor; whereas, the silvered Teflon was severely damaged in a few hours.

Effect of Sea-Water Vapor

An artificial sea-water solution was prepared from a standard receipe.[1] One sample of each material was exposed to the vapor of this solution in a sealed container at 24°C for three days. During this time, dry nitrogen was percolated slowly through the solution. The bursting bubbles served to propel the dissolved salts into the vapor,[2] which otherwise would contain only water molecules.

After exposure, each sample was divided in half. One set of samples was exposed to a vacuum for two days. The second set remained in a normal environment for 14 days; then it was also exposed to a vacuum for two days. The reflectivity of the samples in the wavelength region of 1 to 5 μm was measured. This wavelength corresponds to the near-infrared region of the solar spectrum.

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Table 1 Damage to silvered Teflon caused by exposure to humidity

Experiment no.	Time, hr	Humidity, % 97	92	87	76	55
	1	0	0	0	0	0
	2	0.1	0	0	0	0
1	3.5	1	0	0	0	0
	6	2	0	0	0	0
	24	7	3	0	0	0
	96	10	3	0	0	0
	1.5	0	0	0	0	0
2	2.5	20	0	0	0	0
	5	20	0	0	0	0
	48	60	0.5	0.5	0	0
3	24	12	2	5		
4	48	6			0	0

Table 2 Equivalent humidity vs temperature for occurrence of damage to silvered Teflon

Temperature, °C	Equivalent humidity: Severe damage, >5%	Marginal damage, 0.1-5%	Negligible damage, 0.1%
18			100-78
21		100	92-66
24	97	92-87	76-55
27	82	78-74	65-47
29	71	67-64	58-40
32	66	57-54	48-34
35	51	49-46	41-29
38	44	42-40	35-25

Under these conditions, it was found for both sets that the aluminized Mylar and aluminized Kapton suffered no deterioration; however, the silvered Teflon was severely damaged. This damage took the form of a gentle separation of the silver film from the Teflon. The separation was made manifest by the appearance and growth of white patches over approximately 50% of the surface area observable from the Teflon side. There was no visible effect on the silvered side. Flexing of the material or a gentle contact then caused the silver film to fracture in these areas.

A subsequent test was made on the silvered Teflon with the sea-water solution replaced by distilled water. The occurrence of damage of the same type and magnitude indicated that the water vapor alone, not the dissolved salts, was responsible for deterioration.

Effect of Humidity on Silvered Teflon

In order to determine the range of humidity over which silvered Teflon would deteriorate, samples of the material were suspended above aqueous solution of LiBr in sealed containers. LiBr in water lowers the vapor pressure by a known amount[3] without contributing to the vapor itself.

Table 1 gives the results of these tests in terms of the percent of the surface area damaged. In experiments 1 and 2, samples were exposed to humidities of 97, 92, 87, 76, and 55% at 24°C and observed after specified time periods. In experiments 3 and 4, several other samples were observed after 24 and 48 hr, respectively.

There is considerable variation in the measurable damage for different samples exposed to identical conditions. However, it can be noted that severe damage will occur after only a few hours at the higher humidities. Ninety percent humidity at 24°C appears to be the marginal condition under which some damage, but not severe damage, can occur.

It is obvious that the amount of water vapor present, at a given temperature, determines the degree of damage. Table 2 gives the equivalent humidities, i.e., same water vapor content, at temperatures other than those studied. This chart can be used to predict the degree of damage to be expected under the conditions given. Conditions such as those shown in the second column will produce moderate to severe damage (>5%). The third column presents conditions that produce marginal damage (0.1-5%), whereas the last presents conditions that yeild negligible damage (<0.1%). The validity of this table has been verified by testing samples under conditions of 100% humidity at 18°C and 55% humidity at 14°C.

Acknowledgment

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Errata

Noninteger Transfer Orbits for Circular Orbit Phasing Maneuvers

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THE correct caption for Table 2 is:

Results using the noninteger transfer scheme

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